Prosthetic lower extremity hemodialysis access grafts have satisfactory patency despite a high incidence of infection

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Introduction: **Prosthetic arteriovenous grafts (AVGs) in the lower extremity represent a useful alternative for hemodialysis vascular access when all upper limb access sites have been used or in some patients when freedom of both hands is necessary during dialysis. Reported complications include an increased risk of infection and limb ischemia. This study evaluated our experience with the patency outcomes and complication rates of polytetrafluoroethylene (PTFE) AVGs placed in the thigh.**

Methods: **A retrospective outcomes analysis was performed of all femoral AVGs inserted between January 1992 and July 2007. Data were obtained by review of medical records for patient demographics, comorbidities, and AVG-related outcomes. Patency, complication rates, and risk factors for infection were determined.**

Results: **A total of 153 prosthetic AVGs were placed in 127 patients (63 men). Mean patient age was 52.7 ± 16.3 years. Median follow-up was 25 months (range, 1-169 months). The most common underlying renal disease was glomerulonephritis in 27 (21%). Hypertension and coronary artery disease were common comorbidities, respectively, in 49 (39%) and 23 patients (18%). The primary and secondary AVG patency rates at 12 months were 53.9% and 75.3%, respectively, and 2- and 5-year patency rates were, respectively, 39.6% and 19.3% (primary) and 63.8% and 50.6% (secondary). The mean AVG survival for all cases was 31.6 months (range, 0-149 months). Surgical thrombectomy was required in 82 (54%), and 22 AVGs (14%) required surgical revision for stenosis. Infection occurred in 41 AVGs (27%), and limb ischemia occurred in 2 (1.3%). Statistical analysis did not reveal a significant risk factor for infection.**

Conclusions: **Femoral AVGs are a suitable alternative to upper limb vascular access, with acceptable primary and secondary patency rates. Infection occurred in approximately one-quarter of cases, whereas steal was uncommon. (J Vasc Surg 2010;52:1546-50.)**

Reliable, functioning vascular access is a lifeline for patients with end-stage renal disease who require hemodialysis. According to the National Kidney Foundation Kidney Disease Outcomes Quality Initiative[1] and the European Best Practices Guidelines for Vascular Access,[2] the first choice of a dialysis access conduit is an autologous arteriovenous fistula (AVF) in the lower or upper arm because autologous vein AVFs offer long-term patency along with a low risk of infection.

When no suitable veins are available or after exhaustion of autologous options, a prosthetic AV graft (AVG) can be used to establish permanent vascular access in the arm. When there are no options for AVF in the upper extremities, an AVF can be created in the lower extremity. Surgeons generally reserve access attempts in the lower extremities for situations in which all upper extremity options have been exhausted. Disadvantages of femoral vascular access include the risk of ipsilateral limb ischemia and a higher reported incidence of infection with prosthetic AVG of up to 41%[3-7] compared with 9% in the upper limb.[7]

The aim of this study was to evaluate the use and outcomes of prosthetic lower extremity AVGs at the Royal Prince Alfred Hospital (RPAH), Sydney, New South Wales, Australia. This unit is a tertiary center for vascular access hemodialysis and has a relatively high proportion of patients undertaking home hemodialysis. Home dialysis requires the ability of patients to self-cannulate the dialysis access conduit, which may also be a factor in establishing vascular access in the lower extremity. The major advantage of thigh AVG placement is the possibility for patients to use both hands during dialysis sessions. This series expands on the cohort previously reported by Khadra et al.[5]

METHODS

Patients. From January 1, 1992, until July 1, 2007, 171 polytetrafluoroethylene (PTFE) AVGs were operatively placed in the lower extremity at the RPAH. The analysis excluded 14 patients: 11 were lost to follow-up and 3 died within 30 days of AVG placement of causes unrelated to the access procedure. Four AVGs placed into the

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ipsilateral thigh for a second time were also excluded from the analysis. Data analysis was performed on 153 AVGs in 127 patients using databanks from medical and vascular laboratory records. The data obtained included patient demographic characteristics, medical comorbidities, AVG patency, and vascular access interventional procedures. These data were used to calculate primary, primary assisted, and secondary patencies after 1, 2, and 5 years. Also evaluated were complications reported during the follow-up period, including infection, stenosis, thrombosis, and ischemia caused by access placement. Patient follow-up was a median of 25 months (range, 1-169 months).

Primary AVG patency was defined as the interval from the time of AVG placement until any necessary intervention to maintain normal AVG function or to re-establish patency. Primary assisted patency was the period from placement until access failure, including interventions that were undertaken to maintain access. Secondary patency was defined as the time of patency measurement, including any intervening surgical or endovascular actions designed to re-establish functionality.[8]

The thigh AVGs were placed in a loop configuration between the superficial femoral artery and the adjacent superficial femoral vein in 135 of 153 procedures (88%). In the remaining procedures, the long saphenous vein was used as venous outflow or the common femoral artery was used for the arterial inflow. A more detailed description of the procedure is provided by Khadra et al.[5] All AVGs were made of non-heparin-bonded PTFE but came from different manufacturers. The diameter of the grafts ranged from 6 to 8 mm, depending on the surgeon's choice.

Statistics. Statistical analysis to determine influence of risk factors for infection was performed with SPSS 16.0 software (SPSS Inc, Chicago, Ill). Kaplan-Meier survival curves were generated in GraphPad Prism 5 software (GraphPad Software, La Jolla, Calif). The influence of gender, diabetes, and previous vascular access was examined with the χ^2 test, and influence of age with the Mann-Whitney *U* test. Values of $P < .05$ were considered significant.

RESULTS

Patient characteristics are reported in Table I. Men and women were equally represented in the study group (63 men, 64 women), and the mean age was 52.7 ± 16.3 years. The median patient follow-up was 25 months (range, 1-169 months).

The most common underlying causes of end-stage renal failure were glomerulonephritis, analgesic nephropathy, and diabetic nephropathy. Hypertension was present in 49 patients and was the most commonly reported comorbidity (39%), whereas diabetes mellitus was present in 21 patients (17%). The percentage of patients who had previously undergone vascular access procedures was high (n = 100, 79%).

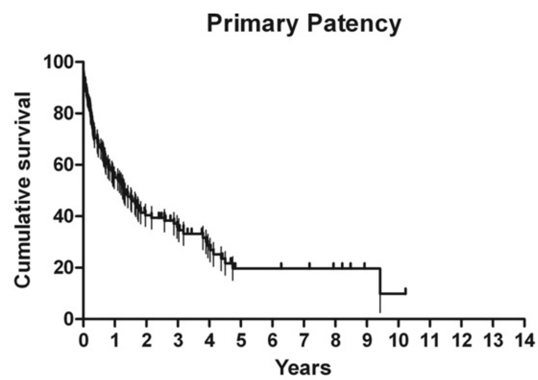
The Kaplan-Meier survival curves for primary and secondary AVG patency are shown in Figs 1 and 2, respectively. Primary graft failure, defined as AVG failure ≤30 days after placement, occurred in eight grafts (5.2%; Table II). The mean AVG survival was 31.6 months (range, 0-149 months). Primary AVG patency and primacy assisted patency after 1 year were both 53.9%; however, secondary patency at 1 year was 75.3%. The 2-year primary and secondary patency rates were 39.6% and 63.8%, respectively, and the 5-year primary and secondary patency rates were 19.3% and 50.6%, respectively (Table II).

The most frequently reported complication of AVG was thrombosis, and a thrombectomy was required in 82 AVGs (54%; Table III). A surgical revision for a stenosis was also required in 22 AVGs (14%). Endovascular repair was not part of the routine treatment protocol during the

Table I. Patient characteristics

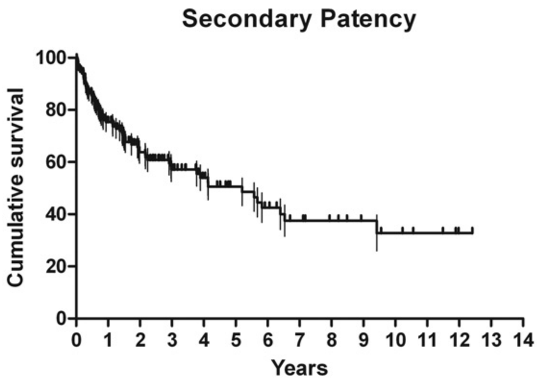
Variable	*No. (%) or mean ± SD*
Patients	127
Age, year	52.7 ± 16.3
Gender	
Male	63
Female	64
Cause renal failure	
Glomerulonephritis	34 (26)
Analgetic nephropathy	13 (10)
Diabetic nephropathy	13 (10)
Vascular nephropathy	10 (8)
Polycystic kidney disease	10 (8)
IgA nephropathy	8 (6)
Reflux nephropathy	7 (6)
Autoimmune	7 (6)
Diverse	23 (18)
Comorbidity	
Hypertension	49 (38)
Coronary artery disease	23 (18)
Diabetes mellitus	21 (17)
Previous vascular access	100 (79)

IgA, Immunoglobulin A; *SD,* standard deviation.



Time (years)	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
Number at risk	153	93	71	56	41	28	18	8	8	7	5	2	1

Fig 1. Kaplan-Meier survival curve is shown for primary patency of polytetrafluoroethylene arteriovenous grafts placed in the thigh.



Time (years)	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10	11	12
Number at risk	153	120	97	81	64	46	33	25	19	14	11	8	6	4	1

Fig 2. Kaplan-Meier survival curve is shown for secondary patency of polytetrafluoroethylene arteriovenous grafts placed in the thigh.

Table II. Patency rates

Variable	*%*
Primary graft failure	5.2
Primary patency	
1 year	53.9
2 years	39.6
5 years	19.3
Primary assisted patency	
1 year	53.9
2 years	39.6
5 years	19.3
Secondary patency	
1 year	75.3
2 years	63.8
5 years	50.6

Table III. Major graft complications

Complication	*Total grafts No. (%)*
Thrombosis/significant stenosis	110 (72)
Requiring thrombectomy	82 (54)
Requiring surgical revision	22 (14)
Endovascular treatment	6 (4)
Infection	41 (27)
Graft excision and replacement	15 (17)
Total graft removal	26 (10)
Pseudoaneurysms	11 (7)
Steal syndrome	2 (1)

study period, and was only applied in six AVGs (4%). Pseudoaneurysms requiring an intervention were seen in 11 AVGs (7%).

Clinically significant infection occurred in 37 patients (29%) with an AVG, defined as grade II severity according to the Society for Vascular Surgery/American Association for Vascular Surgery standards,[8] plus another 4 patients sustained infection in their second AVG. The overall AVG infection rate was therefore 27% (n = 41). Infections that were adequately treated by antibiotics, without surgical drainage or revision, were regarded as minor and were excluded from this analysis. Surgical removal of the entire AVG was required in 26 of 41 cases (63%). Three patients who required total AVG removal also underwent a sartorius flap procedure to cover the femoral vessels. In the remaining 15 infected AVGs (37%), salvage of the vascular access was achieved by means of partial excision of the infected section and interposition bypass grafting. One additional interposition procedure was performed after 57 days because of progressive infection.

Table IV. Risk factors for graft infection

Variable	*No infection No. (%)*	*Infection No. (%)*	P
Age, mean rank	63.7	64.7	.89[a]
Male gender	46 (51.1)	17 (45.9)	.60
Diabetes mellitus	17 (18.9)	4 (10.8)	.27
Hypertension	42 (46.7)	18 (48.6)	.84
Coronary artery disease	19 (21.1)	4 (10.8)	.17
Previous vascular access	74 (66.0)	26 (63.0)	.14

[a]Mann-Whitney *U* test.

Two patients died of cardiac complications ≤30 days after management of the infection. There was no limb loss due to infection. The analysis of the possible effect of patient factors on AVG infection (Table IV) revealed no significant correlation between the occurrence of infection and gender, age, underlying comorbidities, or having undergone previous vascular access ($P > .05$).

Only two patients (1.6%) in our series had signs or symptoms of impaired ipsilateral limb arterial circulation. One patient was managed by means of operative tapering of the AVG to diminish the steal. The other patient required manual compression of the AVG to facilitate rapid AVG thrombosis/occlusion after presenting with critical ischemia of the toes. The patient required below knee amputation 6 months later due to progression of medial calcific peripheral arterial disease.

DISCUSSION

Although the upper extremity remains the favored location for vascular access, thigh AVGs are still an option in some patients, as reported in the literature, when upper arm sites have been exhausted.[3,7] To our knowledge, this is the largest reported series of thigh AVGs. The 1-year primary and secondary patency rates of AVG in this series of 53.9% and 75.3%, respectively, are comparable with other series that have recently reported primary and secondary patency rates for PTFE thigh AVG after 1 year of 34% to 71% and 68% to 83%, respectively.[3,9,10]

Secondary endovascular AV procedures at the RPAH have usually been done only on autogenous fistulas. Because we performed few endovascular treatments during the study period, this might possibly explain the differences in primary patency in this series compared with published reports of 34% to 71%,[3,9-11] although our AVG patency rate is comparable with the 71% patency rate of Tashjian et al.[9] Also, because varying methods of reporting AVG patency have been used, it is not possible to accurately compare our AVG patency rates with series reported by Khadra et al,[5] Korzets et al,[6] Taylor et al,[11] or Bhandari, et al.[12] Miller et al[7] reported the outcomes of thigh AVGs compared with upper arm fistulas, but reported the median intervention-free and thrombosis-free intervals instead of AVG patencies after 1 year. A large multicenter study also reported that the primary patency for forearm prosthetic grafts was 44% and the secondary patency amounted to 79% after 1 year.[13] Thus, the patency rates for thigh AVG in this study are comparable to these published results. They are also comparable to the weighted mean primary patency of 48% and the secondary patency of 69% in thigh dialysis access conduits in the recently reported meta-analysis by Antoniou et al.[10]

Of note in the earlier reported experience at the RPAH, the mean AVG survival time after exclusion of patients who died or received a transplant with a functioning AVG was 99.8 weeks (24.9 months).[5] In the current series with the overall mean AVG survival time of 31.6 months, there seems to have been a slight improvement in AVG outcome during the last decade.

The prevalence of clinically significant infection in our study group was 27%, which is comparable to the 5% to 41% prevalence in other reports.[3-7] Infection remains the most common reported complication after thigh AVG placement, and this complication is one of the major reasons upper arm AVGs are favored in vascular access guidelines,[1,2] In the series by Miller et al,[7] access loss as a result of infection was 11.% for thigh AVGs vs 5.2% for upper arm grafts. This is similar to our series, where 26 AVGs (17%) were lost due to significant infection, which is similar to that reported in the meta-analysis by Antoniou et al.[10]

The ability to salvage 15 (37%) of the infected AVGs by means of partial excision and insertion of an interposition graft meant we could prevent loss of the access site and dialysis could be continued without the longer-term need for a tunneled dialysis catheter. This approach has been reported by Ryan et al,[14] who documented a successful outcome with this technique for infected upper arm AVG in 17 of 23 cases (74%). Cull et al[3] also reported segmental resection for salvage of infected grafts, but not the overall success rate. The report by Schwab et al[15] on this approach included three thigh AVGs.

Also of importance for infected thigh AVG was the application of sartorius muscle flap transposition[16] in three cases to cover the femoral vessels to protect the vessels from further infection, which can eventually lead to limb loss. Sartorius muscle transposition has been described in the setting of infection related to femoral vessels after other vascular surgical procedures.[16]

Within the setting of vascular access for hemodialysis, infection is a known major problem, accounting for 15% of deaths of end-stage renal disease patients.[17] Most infections are caused by *Staphylococcus aureus*[18] and bacteremia is frequent. Because the proximal thigh AVG is located near the groin, bacterial contamination is more likely to occur.[7,19] The patient mortality rate of 2 of 127 (1.5%) related to the preceding requirement for surgical management of an infected AVG in this series is lower than the 4% reported by Cull et al.[3]

Apart from the risk of systemic sepsis with AVG infection, loss of the access is also a major complication. In our series, 26 AVGs had to be abandoned because of infection, with the patients having to receive dialysis using alternative methods and subsequently undergoing further access procedures; however, no patient died due to lack of dialysis access.[3]

Impaired ipsilateral limb arterial circulation is the other major complication seen with the use of thigh AVGs. This condition was seen in only two cases (1.6%) in our series, which is lower than the incidence of ischemic complications of 7.18% in a recent meta-analysis.[10] The discrepancy in incidence of ischemia might be related to our relatively young group of patients (mean age, 52.7 years) and stricter patient selection. Patients who showed signs of peripheral arterial disease on clinical examination were generally not eligible for thigh AVG insertion, and when doubt existed, duplex ultrasound imaging of the distal arterial tree was performed. The result of this very strict selection of patients might explain the low incidence of ipsilateral limb ischemia in our series. This practice is a continuation of that reported in the earlier study of Khadra et al[5] at the RPAH. This approach is also mentioned by Miller et al,[7] where there was also careful evaluation of the lower extremity before thigh AVG placement, and no ischemic complications were reported.

Although our study contains the largest number of femoral AVG cases and a long follow-up period, we realize that graft materials and endovascular techniques have evolved during this period, which is a disadvantage of our analysis. More frequent use of endovascular interventions might improve the patency of femoral AVGs in the future.

Considering the acceptable patency rates but the higher infection risk compared with upper limb AV access, we believe that upper thigh AVGs are an established third-choice option for vascular access after exhaustion of forearm and upper arm access locations. Gradman et al[20] also showed reasonable outcomes with autologous lower extremity AVFs by means of femoral or saphenous vein transposition. In their initial experience, however, steal syndrome occurred in 8 of 25 patients, which could be improved by intraoperative tapering and different patient selection.[21]

The current alterative for most patients who are candidates for femoral vascular acces is a permanent cuffed central venous catheter, which is not a durable long-term solution. According to the European Best Practice Guidelines for Vascular Access,[2] femoral access should be performed before choosing a central venous catheter. The reported relative risk of bloodstream infection can be significantly higher with cuffed central venous catheters compared with AVGs (8.49% vs 1.47%).[22] Lee et al[23] also emphasized the need to confine the use of catheters, regarding their calculated number of 2.6 to 3.2 catheter-related infections per 1000 catheter days. Also, patient mortality, reported as the 1-year crude death rate by Xue et al,[24] was 41.5% for catheters and 28.1% for synthetic grafts.

CONCLUSIONS

The patency rates in this large series of femoral AVGs are acceptable, and the complication rates of infection and steal are comparable to those reported in the literature, with a low incidence of lower limb ischemia. We conclude that femoral AVGs offer a satisfactory alternative for patients who are not good candidates for upper limb vascular access.

AUTHOR CONTRIBUTIONS

Conception and design: IG, DV
Analysis and interpretation: DV, IG, MS, GW
Data collection: IG, LN, VM
Writing the article: IG, DV, GW
Critical revision of the article: IG, DV, GW
Final approval of the article: DV
Statistical analysis: IG, DV
Obtained funding: Not applicable
Overall responsibility: DV

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